VOLUME V NUMBER 6

BULLETIN

OF THE

AMERICAN ASSOCIATION

OF

PETROLEUM GEOLOGISTS

NOVEMBER—DECEMBER, 1921

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

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THE BULLETIN is the official publication of the Association, and it is to be published in six numbers with a subscription price of $5.00 per year. Extra postage on annual subscriptions is 30 cents for Canada and 53 cents for all other foreign countries to which postage is more than the local amount. Communications for the Editor and manuscripts should be addressed to R. C. Moore, Lawrence, Kansas. Remittances and business correspondence should be sent to C. E. Decker, Norman, Okla. Correspondence regarding advertisements should be addressed to E. DeGolyer, 65 Broadway, New York City.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

Vol. I	$2.50	Vol. IV, Nos. 1, 2, or 3, each	$2.00
Vol. II	2.50	Vol. V, Subscription, 1921	5.00
Vol. III	4.00	Vol. V, Nos. 1, 3, each	1.00
Vol. IV, 1, 2, 3	5.00	Vol. V, No. 2 (double size)	2.00

Vol. I, Sold only in complete sets.

Published by the American Association of Petroleum Geologists bimonthly, at Lawrence, Kansas. Entered as second class matter April 15, 1921 at the postoffice at Lawrence, Kansas under the Act of March 3, 1879. Claims for non-receipt of the preceding Numbers of the Bulletin must be sent to the Editor within three months of the date of the receipt of this number in order to be filled gratis.

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NOVEMBER—DECEMBER, 1921

DESCRIPTION OF OIL AND GAS AREAS IN TENNESSEE AND CONDITIONS AFFECTING NEW AREAS

By Wilbur A. Nelson

Wilbur A. Nelson, State Geologist of Tennessee, Nashville, Tennessee.

PHYSIOGRAPHY OF TENNESSEE

A general knowledge of the three major divisions known as East, Middle and West Tennessee and the prominent structural features of these divisions is necessary to a comprehensive view of present and future oil developments in the state.

East Tennessee. East Tennessee consists of the Unaka Mountains, (the boundary mountains between North Carolina and Tennessee) and the great valley of East Tennessee, made up of a series of parallel valleys and ridges with the strata steeply folded and in many places faulted. The rocks are of Ordovician and Cambrian ages and are so faulted and folded that it can be stated positively that no oil exists in the section underlain by them. East Tennessee is separated from Middle Tennessee by the Cumberland Mountains, a plateau standing at an elevation of about 2,000 feet above sea level. This plateau is capped by Pennsylvanian rocks and underlain by a well developed series of Mississippian limestones, from which oil is now being produced in Scott County.

Middle Tennessee. Middle Tennessee consists of a large anticlinal basin, elliptical in shape, known as the Nashville basin, which is the southern extension of the Cincinnati arch. This elliptical basin is about 80 miles long and 40 miles in greatest width. Its longer axis has a northeast and southwest direction. The center of this eroded dome is at Murfreesboro, where Ordovician rocks of the Stones River group outcrop (Plate 1).

Surrounding the Nashville basin on all sides is the Highland Rim, a plateau about 500 feet higher than the Nashville basin, and lying at an elevation of about 1,000 feet above sea level. This plateau occurring on all sides of the Nashville dome, capped by Mississippian strata, and lying on the structural flank of this dome, where local conditions are favorable, is the possible oil field of middle Tennessee.

West Tennessee. West Tennessee is that part of the state lying beyond the western Highland Rim of Middle Tennessee, which rim is separated from West Tennessee by Tennessee River. All of West Tennessee, with the exception of a few

limestone outcrops along Tennessee River, is covered by the Gulf embayment deposits of Quaternary. Tertiary and Cretaceous ages. These consolidated sands and gravels, with thick beds of clay, dip westward from Tennessee River towards Mississippi River at the rate of about 25 to 30 feet to the mile, so that the Upper Cretaceous beds which outcrop just west of Tennessee River are at least 2,000 feet deep at the Mississippi.

DESCRIPTION OF OIL AREAS

CUMBERLAND PLATEAU

Glenmary Area. The Glenmary oil district, opened in 1916, lies in Scott County, on the Cumberland Plateau, and is tributary to the Queen and Crescent division of the Southern Railway system, in what is known as the northeastern division of the Tennessee coal field. This part of the Cumberland Plateau is dissected deeply by the main creeks and streams, and the producing wells are along these different streams at elevations ranging from about 1,250 to 1,500 feet above sea level.

Production comes from the St. Louis limestone, of Mississippian age, at a depth of 1,300 feet to 1,450 feet. The top of the limestone is 680 feet above the top of the Chattanooga "black" shale[1]. Fissuring, not structure, controls the production, and offset wells produce from different fissures at different stratigraphic levels. Surface exposures in the surrounding region do not show structure and either folding or dolomitization is believed to be necessary for a large accumulation of oil. Developments have been slow because of the uncertainty of finding fissures.

Wells yield about 10 barrels of oil daily and some of the oldest wells have maintained a steady production of 5 to 6 barrels for a year or more[2]. The oil is accompanied by gas, but not by water. Several gas wells of 1,000 cubic feet capacity have been completed. The oil is 36.2° Be., has a dark brown color, paraffine base, and contains .17 percent sul-

[1]Glenn, L. C., Resources of Tennessee, Volume VIII, No. 3, p. 215, 1918.
[2]Purdue, A. H., Resources of Tennessee, Vol. VII, No. 2, 1917.
Glenn, L. C., Resources of Tennessee, Vol. VIII, No. 3, 1918.

phur.[3] Production during 1920 was 13,939 barrels, worth $4.00 a barrel.

Northeastern Coal Field. The Glenmary oil district lies on the western edge of the northeastern coal fields, which is that part of the Cumberland coal field lying east of the Queen and Crescent division of the Southern railway, and comprising parts of Anderson, Campbell, Clay, Morgan and Scott counties. Conditions similar to those existing at Glenmary, may exist at other places in Scott, Anderson, and Morgan counties, but it is very doubtful if favorable conditions exist in that part of Claiborne County which lies on the Cumberland Plateau, or on that part of Campbell County lying east of the Southern railroad extending from Caryville to Newcomb, as in this area there has been considerable faulting of the oil bearing formations, bringing them to the surface in a number of places. West of this line the amount of carbon in the coal is, however, sufficiently low to indicate that there is a possibility of finding either oil or gas. A preliminary investigation of Anderson County, west of Briceville and Coal Creek, would indicate the possibility of some minor folds on the anticlinal rise extending northwestward from the two towns just named. Such folds, if they are of a favorable character, may produce gas wells from strata of the lower Pennsylvanian age, or from the Mississippian limestones which underlie the Pennsylvanian.

Cumberland Plateau north of the Tennessee Central Railroad. The Cumberland Plateau north of the Tennessee Central railroad lies on the west side of the Glennary oil district, and comprises parts of Scott, Fentress, Morgan, Overton, Pickett and Cumberland counties. Pennsylvanian rocks also cover this part of the plateau, but their thickness is only a fraction of the thickness developed in the northeastern coal field just mentioned. The Pennsylvanian rocks become thinner westward across the plateau, until on the western escarpment of the plateau, in Pickett County, 200 feet of Rockcastle sandstone lie between 25 and 200 feet above the Mississippian series.

[3]Resources of Tennessee, Vol. VIII, No. 3, p. 213-214, 1918.

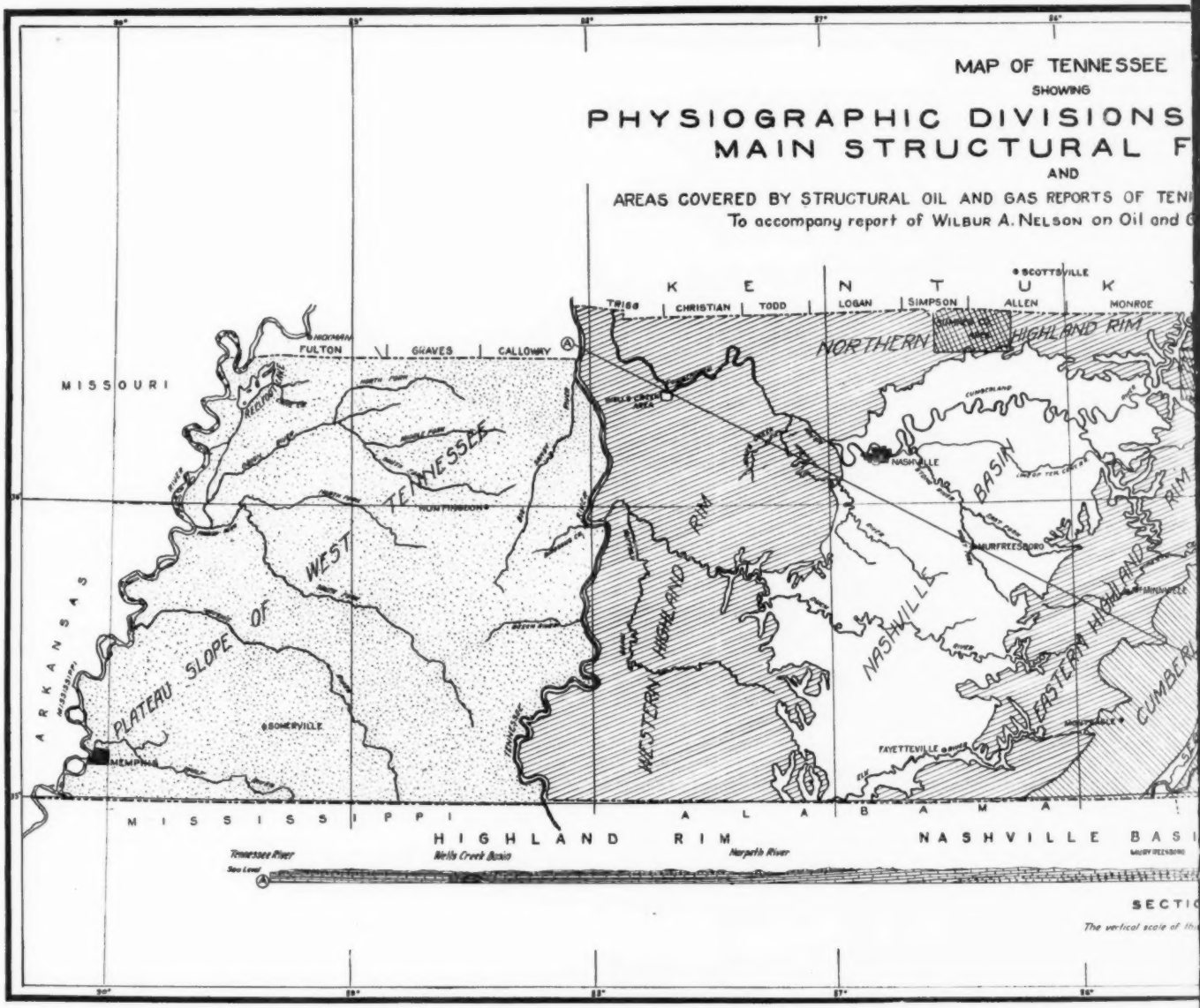
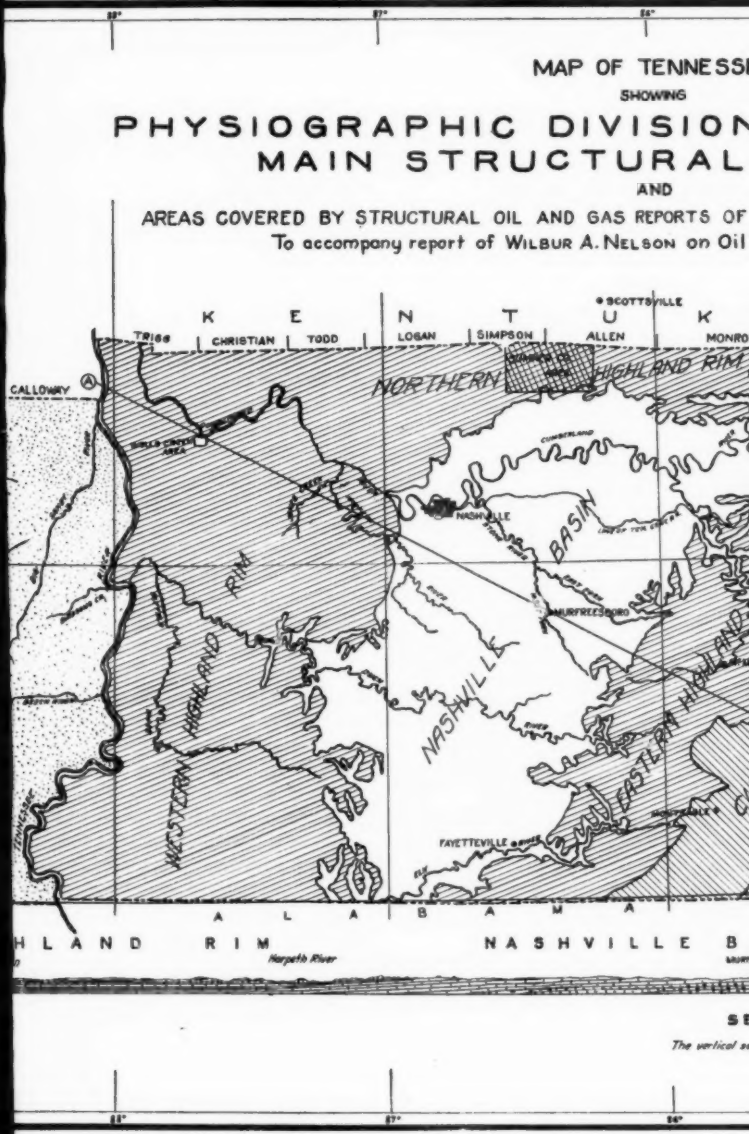
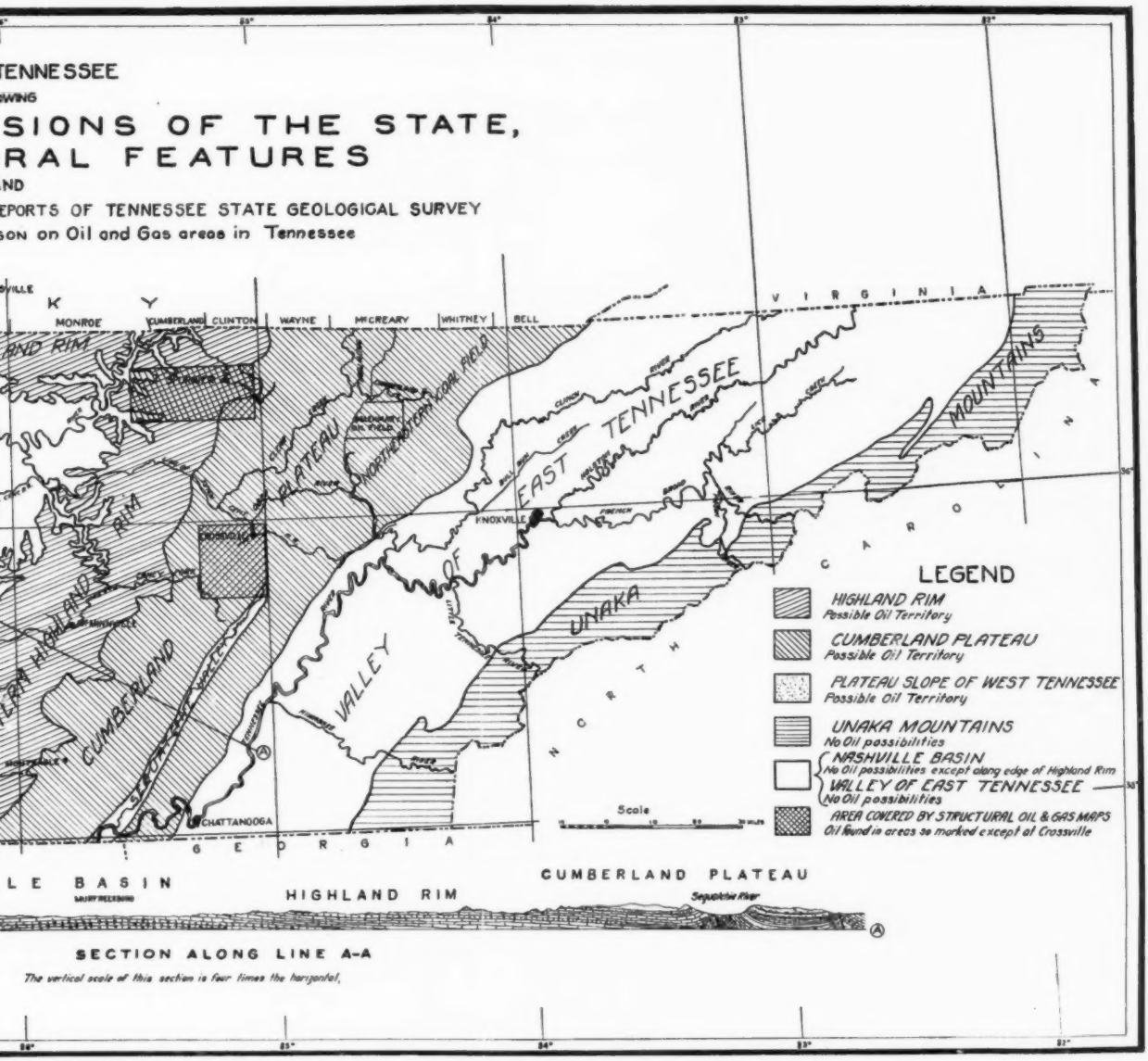


Plate I. Map of Tennessee showing physiographic divisions of the state, main structural features and a



see showing physiographic divisions of the state, main structural features



l features and areas covered by structural oil and gas reports of Tennessee State Geological Survey.

Throughout all of this area there are possibilities of oil and gas in the Mississippian rocks under conditions similar to those existing at Glenmary, and, in addition, from the Ordovician rocks lying a short distance below the Chattanooga "black" shale as in the Spurrior-Riverton field. On the top of the plateau in this section wells should be drilled to a depth of 1,500 feet below the Chattanooga "black" shale, which can be expected at depths of about 1,200 to 1,800 feet.

Cumberland Plateau south of the Tennessee Central Railroad. The Cumberland Plateau south of the Tennessee Central railroad can also be considered as possible oil and gas territory. This part of the Plateau which comprises parts of Cumberland, Van Buren, Bledsoe, Grundy, Sequatchie, Marion and Franklin counties, is capped by Pennsylvanian rocks which have a thickness on the western escarpment of from 100 to 200 feet, and on the Sequatchie Valley escarpment of from 300 to 800 feet.[4] Of the well defined anticlines, the Vandever anticline, in Cumberland County, was drilled in 1918. Because of a bad hole a depth of only 1,820 feet or 20 feet below the Chattanooga "Black" shale was reached and no showing of oil was found. A report by the writer made on parts of Franklin, Marion, and Grundy counties in 1916, showed the presence of well defined structure suitable for the accumulation of oil and gas. At Monteagle there are favorable locations for drilling on the north side of the railroad at this station. Other favorable locations are near Wonder Cave, just north of Monteagle, and at the old Shakerag mines near St. Andrews. The most favorable structures on the northern end of the area mapped are in the heads of Hubbard's Cove and Fultz's Cove, and also on a well defined terrace just west of Altamont. In this southern part of the plateau the possible oil horizon is just below the Chattanooga "black" shale, which should be reached at a depth of about 1,300 to 1,400 feet. To make a thorough test the drilling should be carried 500 feet below the Chattanooga "black" shale.

EAST HIGHLAND RIM

Spurrior-Riverton oil field. The Spurrior-Riverton oil field is located around the town of Spurrior, in the counties of Pick-

[4]Butts, Chas., Resources of Tennessee, Vol. VI, No. 2, p. 107-110, 1916.

ett, Fentress and Overton, in the northeast corner of the Highland Rim, at the foot of the Cumberland Plateau. This is the oldest oil producing area in the state, the first successful well having been in 1892. However, according to Munn[5], a well bored or dug in 1820, one mile above the mouth of Wolf River, is said to have furnished sufficient oil to cover the river, and when set on fire to have produced a "terrible conflagration." Another old well dug, in 1837 on Obey River and about four miles below the mouth of Wolf River, is also said to have furnished a large flow of oil.

In 1892 the Lacey well No. 1 is reported by Compton, in a letter to Butts[6], to have flowed for a short time at the rate of 800 barrels per day. Great trouble was experienced, however, in preventing invasions of fresh water into the well. Drilling was continued in this section and in 1896, the "Bobs Bar" well came in at a depth of 275 feet. Mr. Compton states that this well started off at the rate of 600 barrels per day, but soon settled to a daily production of 22 barrrels. In 1904 the Cumberland Pipe Line Company laid a two inch pipe into this field. This line was taken out in September, 1906, partly because of an annual tax of $10,000.00 placed on it and partly because of fresh water troubles in the oil field and the very low market price of oil at that time. The total amount of oil piped from the Spurrier-Riverton field during the short time the pipe line served this district was 58,776 barrels. All of this oil came from the James Woods farm at Riverton, and the greater part of it from "Bob's Bar" well. Between 1906 and 1919 there was little activity.[7]

The rocks on the surface over most of the area are of Mississippian age. The oil horizon is a limestone of Ordovician age from 165 to 275 feet below the Chattanooga "black" shale. The general dip of the rocks is to the southeast, and the rather sharp, low domes, anticlines and synclines trend in a general

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[5]Munn, M. J., Tennessee Geological Survey Bull. 2-E, Oil and Gas Development in Tennessee. 1911.

[6]Butts, Chas., Geology and Oil Possibilities of the Northern Part of Overton County, Tennessee, and the Adjoining Parts of Clay, Pickett, Fentress counties, Tenn. Geo. Surv., Bull. 24, pt. 2A, 1919.

[7]Butts, Chas., Ibid.

northeast-southwest direction. The depth of the wells varies between 270 feet in places west of Livingston and in the stream valleys, and 1,300 feet on the edge of the Cumberland Plateau.

There has been considerable drilling in this section during 1920, and several producing wells have been brought in. An examination of cuttings from a number of these wells shows the presence of a bed of bentonite, two to four feet thick, which occurs near the top of the Lowville formation of the Black River group of Ordovician age. This bed of volcanic ash or bentonite is readily recognized by the drillers and can be used as a horizon marker.[8] It occurs 513 feet below the Chattanooga "black" shale in the Crawford well No. 1., near Crawford Mills, Overton County. The natural outcrop of this bed has been studied in detail at Shelbyville. In Middle Tennessee, the Lowville formation lies directly below the Hermitage formation of the Trenton group.

A four barrel well was brought in on the Crawford Mill anticline at the south side of Roaring River, just above the steel bridge. This oil comes from 433 feet below the Chattanooga "black" shale.

Crawford No. 1, drilled in 1920, produced 4 barrels from 632 to 659 feet, 459 feet below the top of the Chattanooga. The Livingston Electric Light Company obtained some oil from the Romanian Oil & Gas Company's No. 1, on Obey River, near the mouth of Eagle Creek. Oil was found at 325 feet and from 365 to 377 feet and the total depth was 726 feet. The upper sand carried oil of 39.° Be., with 17.5 percent kerosene of 43.7° Be., and 22.5 percent gas oil of 36.0° Be.

The Holbert Creek well, 1½ miles west of Forbus, in Pickett County, found the Chattanooga from 195 to 217 feet, bentonite 748 to 752 feet and Lower Ordovician or Cambrian oil sand from 1552 to 1617 feet. Fifteen feet of limestone was drilled through below the oil sand. The sand shows an analysis (by Dr. J. I. D. Hinds) $CaCO_3$ 52.14 percent $Mg\ CO_3$ 37.83 percent Fe_2O_3, Al_2O_3 1.13 percent, insoluble 8.43 percent.

The well was shot with 120 quarts of nitro-glycerine February 2nd, 1921, and flowed for one hour. The oil is 37.6° Be., dark brown in color, paraffine base, shows 23.8 percent of 65.2° Be., gravity up to 150° C, 37 percent, burning oil of 44.9° Be., gravity from 150°-300° C, 39.2 percent residue (computed) of 32.6° Be., gravity and .18 percent sulphur.

Water troubles have retarded developments. These can be over-

[8]Bentonite is an altered volcanic ash which was thought to occur only in the Rocky Mountains section of the United States, until this bed was discovered by the author in October, 1920.

come by setting casing above the first gas show. Gas occurs at various horizons in the Ordovician limestone and the gas sands and pockets are frequently connected with the underlying oil sands by joints or fractures

Eastern Highland Rim South of Spurrior field. Some drilling has been done south of the Spurrior-Riverton field, on the eastern Highland Rim, but none of the wells is known to have been drilled where the geologic structure was favorable. Preparations are now being made to drill several wells in the southeastern part of Warren County and the northwestern part of Grundy County, on structure which has recently been worked out in detail. The horizons to be tested are the same as those from which oil is now being obtained in the Spurrior-Riverton field. One well drilled in the past year, just east of McMinnville, the county seat of Warren County, started in the Mississippian limestone, entered the Chattanooga "black" shale at 172 feet, and passed through it at 206 feet. Shows of gas were encountered at 100, 300, 375, 386, and 478 feet. A show of oil was found about 14 feet above the Chattanooga "black" shale at a depth of 158 feet, at 208 feet, at the base of this shale, and between 375 and 386 feet. The well was drilled to a depth of 546 feet.

NORTHERN HIGHLAND RIM

Sumner County Oil Field. The Sumner County oil field was developed in 1920, after the publication of a report by Mather[9] who showed that up to that time no well had been drilled on structure. Four wells drilled during the year on the Dutch Creek anticline are producing five to twenty-five barrels daily from a depth of 250 feet. The oil is found 65 to 80 feet below the Chattanooga in the same oil sand found in Allen County, Kentucky. The oil is 32° Be. gravity, dark brown in color, shows 16.3 percent naptha of 59.7° Be. gravity up to 150° C., 50 percent burning oils of 36.7° Be. gravity from 150° to 300° and 33.7 percent residue of 15.7° Be. gravity over 300° (D. F. Farrar, Analyst). Oil sand shows $CaCo_3$ 61.24 percent, Mg CO_3 33.02 percent, Fe_2O_3 Al_2O_3 1.86 percent Mg CO_3 1.86 percent insoluble 3 percent.

[9]Mather, Kirtley F., "Oil and Gas Resources of the Northeastern Part of Sumner County," Pt. B, Bull. 24, Tenn. Geol. Surv. 1920.

Wells start in the basal Mississippian, penetrate the Chattanooga "black" chale, the "Corniferows" beds (occasionally containing oil sands), and obtain production from dolomitic layers in the Louisville formation, of Silurian age, and the Laurel formation, of Silurian age. This Silurian horizon should produce on favorable structure in adjacent counties and one two-barrel well has already been completed at 215 feet on the Doss farm in Macon County.

In the vicinity of Scottville, Allen County, oil may be found in any one of three district horizons. The upper and in some places, the upper two sands are believed to represent the Pegram ("Corniferous") limestone, of Devonian age. The lower, and most productive sand south of Scottsville, is thought to be in the Louisville limestone because the "Corniferous" beds are absent.

The Pegram shoreline probably extended from Newsome station, northeastward through Cheatham and Robertson counties (near Springfield), past the northeast corner of Robertson County. This limestone is 3 feet thick at Newsome station and 12 feet thick at Pegram. All the territory from this line west to Tennessee River is underlain by it.

The boundary of the limestone phase of the Louisville formation of Silurian age, which is supposed to be oil bearing, lies not far southeast of the present edge of the Highland Rim, in the Middle Basin of Tennessee as far south as Pegram. Thence it turns northwest and swings back into Kentucky. Suitable thickness is confined to the northern parts of Sumner and Robertson counties.

Dickson County. Oil was first found in Dickson County, on Jones Creek in 1866. According to Munn[10] a well drilled on the G. W. Brown farm struck oil at a depth of 295 feet and flowed 13 barrels in thirty minutes. Oil from another well in this same locality was shipped to Nashville. It was said to have had a gravity of about 42° Baume. Although the early wells made excellent showings, only ten wells were completed prior to 1910. Several additional wells were drilled

[10]Munn, M. J. Preliminary report on oil and gas in Tennessee, Tenn. Geol. Surv. p. 34, 1911.

during 1919 and 1920. A number of other wells are now being drilled in this section, and one of these on the Henry Taylor farm, near White Bluff, on Thrace Creek, has reached a depth of 1378 feet. This well passed through the Chattanooga "black" shale at 114 feet, obtained a show of oil between 361 and 379 feet, and a gas pocket at 610. It is thought that the gas show was found in the Hermitage formation of Trenton age.

Recent work south of Dickson County at Centerville, in Hickman County, shows that there is in that region an angular unconformity existing at the base of the Chattanooga "black" shale. This is clearly shown in an exposure in a bluff on Duck River, where the Chattanooga "black" shale has a dip to the south of 2½ degrees, and the underlying Clifton formation of Silurian age a dip southward of about 5 degrees.

NASHVILLE BASIN

The Nashville basin is structurally a large dome, centering at Murfreesboro, the county seat of Rutherford County, in which strata of the Stones River group, of Ordovician age, outcrop. The Trenton limestone and Hermitage formation underlie only the outer edges, and shows of oil have been found in the latter at a depth of about 60 feet near Mulberry. Tests on structure may yield one barrel or less daily. The oil is 32.8° Be. gravity, dark brown in color, with paraffine base, is very low in gasolene and high in burning oil.

WEST TENNESSEE

Reelfoot Lake District. Three wells were drilled near Reelfoot Lake in 1920. The Reelfoot Ranger Oil Company well at Walnut Log was abandoned at 1,240 feet, and their Rogers well at 1,650 feet. The Reelfoot Dome Oil Company test at Proctor City, 2,075 feet deep, penetrated the Selma formation, which may rest in this area directly on the Paleozoic floor of the Gulf embayment. The log is interpreted as showing: Quaternary and Pliocene 300 feet, Lagrange formation (Tertiary) 965 feet, Porters Creek formation

(Tertiary) 385 feet, McNairy and Ripley formations (Cretaceous) 324 feet, and Selma formation (Cretaceous) (with fossils) 99 feet.

Another well now drilling at Bondurant, Kentucky, by Roney Mitchell & Bruer is at a depth of over 2,700 feet.

Exposures of hard clay and sand below the loess bluffs have been used as a basis for structural investigations. It is thought that a contact between the thin yellow sandstone and gray limey clay which occurs throughout this region can be used as a basis for working out the structure in detail. This work indicated the probable existence of several anticlines: One is located northwest of Reelfoot Creek, extending into Kentucky; one near New Idlewild; one near Union City, south of Fremont; another along Cane Creek south of the L. Maupin home; another at Gratio.

Carroll County. A well defined plunging anticline is being tested by the Johnson Refining Company at a point two miles southwest of Huntingdon, Carroll County. The well, which started in the Porters Creek formation, was abandoned at 800 feet in the gray micaceous clay of the Eutaw formation, only a short distance above the floor of the Gulf embayment.

Fayette County. There are a number of good exposures of the LaGrange formation in Fayette County within a radius of five miles of Somerville which indicate that the town of Somerville is situated in a synclinal area north of an anticline[11], in the vicinity of the negro school house at Greenville. The Eutaw formation would probably be reached here at a depth of about 1,800 or 1,900 feet.

The above described areas are considered, from our present knowledge, the best regions in West Tennessee for wildcat drilling.

CONCLUSIONS

This summary of the geology and structure of Tennessee, calls attention to the fact that there are many counties in the state where conditions justify drilling for oil and gas, with a fair chance of getting commercial wells. At the present time oil has been found in Scott, Pickett, Fentress, Overton,

Sumner and Macon counties, but lack of transportation facilities has kept any oil from being marketed except from Scott County. Commercial wells will undoubtedly be found in other Tennessee counties if sufficient drilling is done.

[11]Tenn. Geol. Surv. Bull. 23, pp. 33-4, 1920.

SOME RECENT NOTES ON THE THRALL OIL FIELD OF WILLIAMSON COUNTY, TEXAS

By H. P. Bybee

LOCATION AND HISTORY

Thrall is located six miles east of Taylor, Williamson County, Texas. It is on the I. & G. N. Railway.

In 1914, Mr. Fritz Fuchs attempted to drill for water in the southwest corner of his 100 acre farm on the Daniel Kimbro Survey. Little or no water was found, but there was a considerable amount of oil in the well at a depth of 300 feet. Early in February, 1915, arrangements were made to drill deeper for oil and on February 22, 1915, the "discovery well" was brought in.

Very early in the history of the field Dr. J. A. Udden of the Bureau of Economic Geology and Technology of the University of Texas discovered that the oils in one of the wells came from a green igneous rock. This discovery led to the collection of data set forth in Bulletin 66 of the University of Texas by the Bureau of Economic Geology and Technology, which is now out of print.

It seems worth while after six years to put on record the status of the production of the field, and at the same time to bring up question concerning the origin of the oil.

The following table gives the production of Thrall by years to date:

March to Dec. 1915	994,874 bbls.
March to Dec. 1916	461,518 bbls.
March to Dec. 1917	182,567 bbls.
March to Dec. 1918	136,378 bbls.
March to Dec. 1919	92,184 bbls.
March to Dec. 1920	58,883 bbls.
Total	1,926,404 bbls. (42 galons)

From the above table it can be seen readily that there was more oil produced during the first ten months of the life of the

H. P. Bybee, Professor of Geology, University of Texas, Austin, Texas.

field than has been produced in the subsequent five years.

The area of the field is approximately 480 acres, hence the field has yielded about 4,013 barrels of crude oil per acre. With the high state of porosity, which is about 32.2 percent a layer of the igneous rock less than three feet in thickness would be capable of containing all the oil produced so far, and then only one half of the available pore space would be filled with oil. It is worthy of note that considerable production was secured from a very porous "shell breccia" just above the serpentine.

The following table is found on page 60 of Bulletin No. 66 of the University of Texas, with the exception of the column on the right which is added to show the production of the same 32 wells after the lapse of six years:

Well No.	Initial production in bbls.	Six months later in bbls.	Fifteen months later in bbls.	Six months later in bbls
1	400	35	2	½
2	470	40	2	½
3	600	45	1	¼
4	900	35	8	¼
5	878	35	2	¼
6	10	1	1	¼
7	536	35	3	¼
8	50	20	2	¼
9	400	40	10	¼
10	150	25	3	¼
11	50	20	2	¼
12	150	20	1	¼
13	150	65	10	1
14	60	35	2	¼
15	100	10	1	¼
16	20	35	10	1
17	25	35	2	¼
18	400	100	1	1
19	1500	50	0	¼
20	900	60	20	?
21	100	25	1	¼
22	150	25	1	¼
23	100	20	1	¼
24	10	6	1	¼
25	0	0	0	0
26	60	20	1	¼
27	0	0	0	0
28	50	50	1	¼
29	35	30	12	¼
30	40	30	25	¼
31	40	?	1	¼
32	400	100	20	¼
Average	398	30	5	.523

It may be said that the present status of the field is very well represented by the data in this table. In other words, the history of these 32 wells is the history of the field as a whole. On these leases the record of which were available and on which there were 122 wells producing 815 barrels of oil fifteen months after the discovery, 141 wells have been drilled, of which 36 are now entirely dry, and 105 were producing 106 barrels daily during the first week of March 1921, an average of about one barrel per well. Eight of the 105 wells produced 66 barrels, an average of 8¼ barrels per well while the remainig 97 wells produced 40 barrels or an average of .41 barrels daily. The very small production which under these conditions can be profitably utilized is of interest.

SOURCE OF THE OIL

In the Bulletin 66 referred to above the writers suggested that the source of the oil was adjacent shales either above or below the volcanic rock, more probably above. This is probably the correct theory of origin of the oil for the following reasons: (1) very little water is encountered in the field, hence the main collecting agency for oil is absent; (2) there is no typical oil sand through which oil could be gathered from a distance; and (3) the serpentine in which the oil is accumulated most probably has no connection with any possible water-bearing sand and hence could receive very little oil from that source. Therefore in the absence of any considerable volume of water, without any typical oil sand, and with the oil reservoir of local extent, the oil must have come from the adjacent shale and have seeped into the very porous outer layers of the serpentine.

The rapid decline of the field may also be interpreted as evidence of the local source of the oil. The Thrall field has been short lived as compared with other fields in the same formation. Corsicana for instance has been producing since 1896 and even in 1920 is reported to have produced 400,000 barrels of crdue oil. This long and continued production may be taken as indicative of accumulation from a wider range than is available to the reservoir at Thrall.

Studies of shale cuttings secured from a large number of wells, show that on the basis of several characteristics the shales can be divided in four groups. The lowest, 100 feet of shale, resting upon the volcanic rock, is very much richer in bitumens than any other portion of the section. As was shown in Bulletin 66, a comparatively low content of nine gallons of oil per ton of shale throughout a layer of shale 60 feet in thickness lying directly above the volcanic rock, would be equivalent to all the oil produced at Thrall to date.

As to the possibility of the oil migrating from this 100-foot bed of shale into the porous volcanic rock, the writer has nothing to say except that the sand content of this shale is noticeably higher than that of any other portion of the section. This condition may have facilitated the movement of the oil through the shales.

Thus Thrall throws some light upon the accumulation of oil from adjacent shale beds, although the writer cannot explain how the oil at Thrall migrated through the shales into the green reservoir rock. That problem might be made the subject of a separate paper.

GEOLOGICAL NOTES ON THE BELGIAN CONGO

By Wm. J. Millard

INTRODUCTION

This paper consists of some brief notes made by the writer while prospecting for gold and oil in Africa. It was first read in connection with lantern slides illustrating scenes in the Belgian Congo before a meeting of the Tulsa Geological Society. Properly it should contain a discussion of the oil possibilities. Oil shales are found in the Upper Congo region and a bituminous limestone on the west coast.

CONDITIONS

The interior of Africa presents a new and prolific field to the geologist and physiographer. Considerable work has already been done. The field conditions are different from those of the temperate zone, for as is usual in the tropics, outcrops are easily concealed by the vegetation. In the coastal region outcrops are rarely observed outside of the creek and river valleys, but in some places a creek may be followed all the way from its mouth to its source without encountering a rock in place. The mountainous regions are easily examined, particularly in the dry season. At that time the tall grass, which conceals the surface in the wet season, dries and is burned by the natives. One is hampered by the necessity of a large and complete camp equipment, which is essential to the African climate and its vicissitudes. Labor is not always available and if available is not always willing. In general, the daily amount of work accomplished is much less than that of the temperate zone.

POSITION AND AREA

Africa has an area of 11,506,000 square miles and the Belgian Congo an area of 908,000 square miles. The Congo therefore comprises about 1-12th of the entire continent. It begins with a few miles of coast at the mouth of the Congo

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in latitude 6° S. and longitude 11° 30'E., and extends east to about longitude 30° E. broadening out in its widest part to 5° N. and 11° S. The Congo has but one portion of natural boundary, i. e., the Lake of Tanganyika. A truer physiographic boundary would be the west foot of the gigantic horst, which is found here.[1].

PYHSIOGRAPHY

Africa as a continent has a general pleateau-like habit. In the extreme south the Cape Colony Mountains[2] show the Appalachian type of folding. In the extreme north are the folded Atlas Mountains[3] although close by are the regions exhibiting the characteristics of block faulting[4]. The area between is divided into geographical regions such as the great Soudan-Sahara plateau region, the Equatorial[5] and South African Plateau[6] and the East Africa fault block area, including Abysinnia, British East Africa[7], British Central Africa[8], and German and Portuguese East Africa. These plateaus might in places really be considered as broken plateaus and fault block mountains. For example, Ricchieri gives in his Libia Interna, De Matheusieux's structure diagram of Libya showing an apparent series of tilted fault blocks. Collie's description of British East Africa shows block faulting. Davis writes of faulting in the South African veldt. Ball describes faulting in the east of the Haut-Congo and of obscure faulting in the valley of the Lomami River. As a rim around Africa almost everywhere is found a narrow coastal plain, showing, in some places, evidence of recent elevation[9] and in other places, recent depression.[10]

The Congo consists of a coastal plain about 30 miles in width, a transition area containing the tremendous cata-

[1]Ball, S. H., and Shaler, M. K., Jour. Geol., Vol. 18, 1910, p. 681.
[2]Davis, W. M., Bull. A. G. S., val. 38, 1906, pp. 593-623.
[3]Haug, Em., Traite de Geologie, II, 1911, p. 832, also Ball and Shaler.
[4]Smith, F. Fisher, Morocco, Smiths Inst., 1904. Ricchieri, Giuseppe, Libia Interna, Soc. Geog. Ital.
[5]Ball, S. H., and Shaler, M. K., loc. cit.
[6]Davis, Wm., Bull. Geol. Soc. Am., vol. 17, 1906, p. 377.
[7]Collie, G. L., Bull. Geol. Soc. vol. 23, 1912, p. 297.
[8]Sharpe, Sir Alfred, Geol. Jour., vol. 39, 1912.
[9]Collie, G. L. loc. cit.
[10]Davis, W. M., loc. cit.

racts of the Congo, the interior plateau region and the mountainous eastern boundary, which may perhaps be classified as fault block mountains.

COASTAL PLAIN

The coastal plain, near Cabinda in Portuguese territory, begins at the coast with an abrupt cliff about 100 feet high. A narrow strip of beach on the headlands reveals active undercutting. Bays are being filled in, as the cliffs are in some places distant from one to one and a half miles from the water's edge. This is evidence of recent uplift. At the mouth of the Congo the cliffs are distinctly silhouetted against the sky line as a terrace two or three miles back, while the narrow strip of beach here represents what was perhaps at one time part of the bed of the Congo. A short distance back from the coast the river flows between well-defined banks. At Matadi one may observe what appears to be an old river terrace. An exposure of Cretaceous sediments in the Mayumbe and in Angola[11] indicates an uplift at least since Cretaceous time.

This elevated coastal plain is a rolling, flat country which extends eastward for about 30 miles in latitude 5°30-s. In numerous places it is undissected and almost as flat as a billiard table. Its uplift was undoubtedly accomplished by some warping, for a white (Eocene) limestone comes to the surface near the eastern border. Swamps also exist (elevation 150 feet above sea level).

The plain rises gradually from an elevation of 100 feet at the coast to about 600 feet along the eastern border. This is about 30 miles north of the Congo River, where the typical topography is best studied away from the influence of that river. The streams and valleys are youthful to sub-mature. Steep gradients, small waterfalls and small swamps are frequently found close together. The valley walls in many places exhibit very steep sides, due perhaps to undercutting by exuding ground-water and also headward erosion of the streams.

[11]Choffat, Paul, and de Lorol, P., Memoirs de la Soc. de Physique et D'Histoire Naturelle de Geneve, Tome XXX, No. 2, Materiaux pour l'etude Stratigraphique et Palaeontologique de la Province D'Angola, 1888, pp. 1-116.

The vegetation is sparse. Only near rivers and streams do thick growths of trees exist. There are vast stretches of sandy areas covered six months of the year with high grass.

TRANSITION AREA

Continuing eastward on the same parallel of latitude we pass into a region of igneous and metamorphosed rocks. This is distinctly older in its state of dissection than the coastal highland. The region is more or less an up-and-down country, a sub-maturely to maturely dissected plateau. Looking downstream from Matadi on the Congo River one sees an even skyline. The highest part of this transition region is the Crystal Mtns. which run northwest and of which some peaks are 2,300 feet in elevation. Ball[12] writes of the Crystal Mtns. as an old mountain region now eroded to a very thoroughly dissected plateau with a few monadnocks of the former peneplain breaking the continuity of the sky-line.

It is possible that the ascent from the coast plain is made over a series of fault blocks so arranged as to give apparent terraces, of which the Crystal Mtns. represent the highest, the eroded escarpments being unseen unless specifically searched for. A map of the District des Cataracts shows a striking parallelism in the course of the streams which flow into the Congo. This trend is northwest and southeast, a direction which is evidently controlled by some structural feature such as a series of parallel faults. This trend corresponds with the general direction of other structural features in this part of Africa. However, since the maps of the Congo are not as yet very accurate, the above hypothesis may be regarded only as a suggestion.

It may be observed here that Congo River follows a tortuous course across this transition region. From the map one may imagine that at one time in its history the river was mature, marked by meanders. At present, however, it flows across this region in a long series of rapids, and is therefore young and antecedent. There is no doubt that uplift has taken place, but the nature of the uplift is in doubt. The

[12]Ball, S. H., and Shaler, M. K., loc. cit.

flat-lying sediments just east of the Crystal Mtns. would suggest faulting, which might be widespread and a result of isostatic adjustment.

INTERIOR PLATEAU REGION

The interior plateau region comprises the largest part of the Congo. Its western boundary merges into the transition area between Matadi and Thysville. The eastern boundary is along the base of the hills and mountains just west of Lake Tanganyika, and continues south to the Rhodesian border and north to just west of Lake Albert. The northern and southern boundaries are not particularly defined, as the whole interior of Africa is more or less a plateau region. Ball and Shaler[13] call the region an interior basin, on the south of which is a bounding rim of crystalline rocks.

The interior plateau region is now in the sub-mature stage of its second or third cycle of peneplanation. Steep valley walls, broad stretches of undissected areas, swamps, lakes, features of headward erosion and abundance of cataracts are found in this region. Congo River flows through the heart of this area in a great bend. Many of its tributaries show meandering, an evidence of maturity. The meanders of Lomami River in longitude 25 E.-24 E., the Mogala in long. 20 E at 2 N., and the Likuala aux Herbes in French territory near Coquilatville may be noted. In contrast to these regions and within 35 to 100 miles there is evidence of submaturity. Just east of Lomami River, about one half degree of longitude is the Lualaba (Upper Congo) which has an extremely rapid current, is bordered by high banks of sandstones and shale and has numerous rapids.

Other evidence of the second cycle of peneplanation lies in the monadnocks of the Kasai district and the Katanga.[14] Also between Matadi and Thysville to the north of the railroad a typical mesa may be noted. The uplift has been in stages that permitted the development of flood plains in the Kasai[13], as evidenced by terraces.

[13]Ball, S. H., and Shaler, M. K., Ann. de la Soc. Geol. de Belge, 1912-13.

[14]D'Andrimont, Ann. de la Soc. Geol. de Belg., Tome 39, 1912-14.

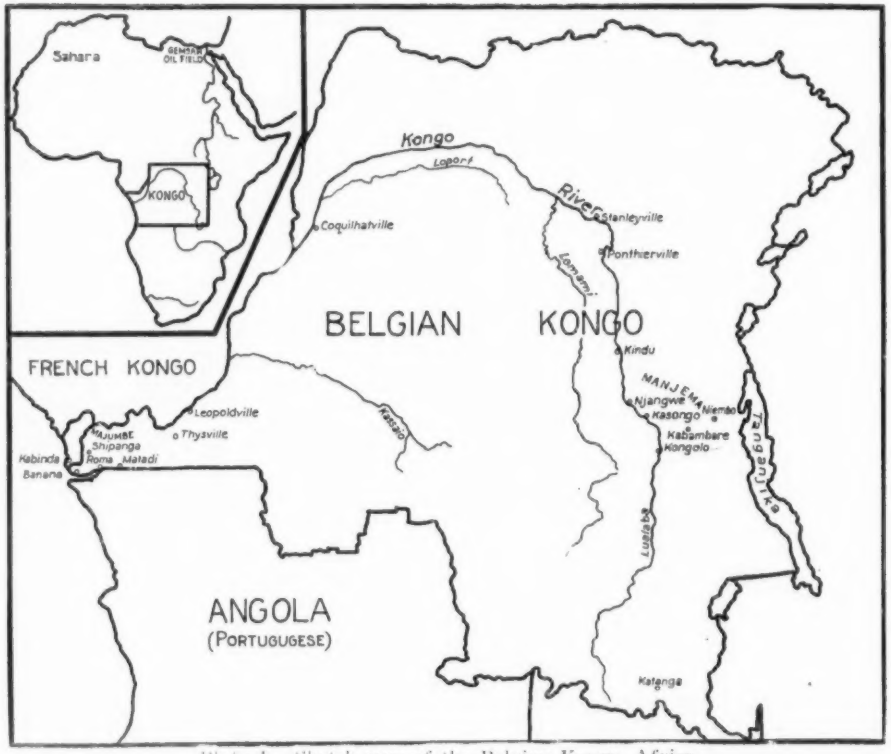

Plate I.—Sketch map of the Belgian Kongo, Africa.

On a map of the Congo there appears a peculiar and possibly significant feature which further supports the theory that the region has suffered base leveling. Along the large rivers like the Congo and the Kasai are tributary streams which flow approximately parallel for long distances before entering the trunk. Between latitude 1° N. and 2° N., the river Lupori for approximately 350 miles flows parallel to the Congo at a distance of about 35 miles. Congo River is here about 7miles wide. It is easy to conceive that such a mighty river flowing in a flat plain in time of flood, would throw up enormous natural levees which would effectively bar tributaries from making a direct entrance. It would be interesting to investigate thoroughly this point in the field.

Correlated with this idea of peneplanation of the interior region is evidence in South and Central Afirca presented elsewhere. G. L. Collie[15] writes about peneplanation in British Central Africa which adjoins the Congo on the southeast. Wm. M. Davis[16] has studied Rhodesia, to the south.

FAULT BLOCK REGION

The fourth physiographic division is only a narrow strip of territory along the eastern boundary of the Congo. It is really a slice from the western edge of the East African fault block area which might better be termed a high plateau region. Because this paper is limited to discussion of the Belgian Congo, the mountains and hills will be considered southward from Lake Albert in the north to Lake Moera and Lake Bangwelo on the Rhodesian border. It includes the mountains west of Lake Tanganyika.

The foundation seems to be the "gnarled and foliated gneisses" of Collie's "gneiss province"[15] of British East Africa. The mountains are probably fault block mountains although in some places the strike of the fault coincides with the strike of the highly tilted or folded metamorphosed sedimentaries. In Collie's article a diagram shows block faulting on an enormous scale. It includes the "Great Rift"

[15]Coolie, G. L., loc. cit.
[16]Davis, W. M., Bull. A. G. S., vol. 38, 1906, pp. 593-623.

and the block east of Lake Tanganyika. "These blocks have a slope toward the ocean (Indian) greater than erosion can account for." He mentions monadnocks and a peneplaned surface as topographical features before the faulting occurred. A topographical map of the district west of Lake Tanganyika between latitudes 4°S. and 5°S., compiled by the Société Internationale Forestiere et Miniere du Congo, shows different features to correlate it with Collie's region.

The elevations of the highest points on this map are approximately 6,000 feet above sea level. Both the east and west sides of the Tanganyika Mountains show typical triangular facets and steep slopes with the consequent drainage of tilted fault blocks. "Splitting" is also shown by the contours and the drainage. For example, Kilombwe River, east of Kalembe Lembe seems to occupy the basin created by one of the splits. It well illustrates a stream in a fault basin with steep consequent tributaries coming from the west blocks and other consequents on the gentler back slope by the eastward block. Luama River to the west, occupies the basin created by the main fault.

Ball and Shaler[17] mention a remnant of flat-lying Lubilache sandstone at the headwaters of Luiko River which is 2,000 feet above the same sandstone that is found on the Niembo Mountains in the lowland to the west. This would indicate either a fault or an eroded fold. In view of the fact that some of the faulting cuts across the structure of the metamorphosed sedimentaries, and that the area is so closely associated with the region containing the Great Rift Valley, the present structure is regarded as due to faulting rather than folding. The similarity in elevation of the high features may cause the region to be designated as a maturely dissected broken pleateu. We may then deduct that if the entire region east of the Congo is a broken plateau region or fault block mountain region the entire eastern boundary of the Congo is similar to the area just described.

[17]Ball, S. H., and Shaler, M. K., loc. cit.

GEOLOGY

The geology is best considered in the order of the four physiographic provinces. In general the coastal plain consists of Cretaceous, Triassic, and Recent sediments, the transition area of folded Paleozoic crystallines and sedimentaries with later intrusions, the interior plateau of Permian and Triassic sediments with outcroppings of the underlying metamorphosed Paleozoic and the high plateau area of metamorphosed Paleozoics, intrusives, Pre-Cambrian (?) rocks and later extrusives.

COASTAL PLAIN

The base of the sediments in the coastal plain is perhaps nowhere better exposed than at Shipanga in the Mayumbe. This is about 35 miles from the Atlantic Coast and on the interior edge of the transition area. The bituminous limestone which outcrops here, rests on soft sandstone and clay beneath which is a gneissoid quartz monzonite. It is interesting to note that bituminous sandstone was found 250 miles south in Angola and also in Gabun about the same distance to the north. In Angola, no fossils were found in the bituminous sandstone; but it appears to be at the base of the Cretaceous sediments. At Shipanga are found the brachiopods, *Cylindrites cordeiroi* (Choffat), *Nerita malheiroi* (Choffat), the ammonite *Schloenbachia elobienses* (Szajn) and other brachiopods.[18] These fossils are Albien or the base of the Middle Cretaceous. There outcrops also some miles northwest, a white limestone which may perhaps be correlated with Choffat's Eocene in Angola. However, the Eocene is not known in the French Congo to the north.[19] The unconsolidated overlying red, white and yellow sands and clays with interstratified limonite conglomerate are presumably recent, although no fossils have as yet been found.

The thickness of the Cretaceous beds was not determined because of local deformation. The recent beds above this show a thickness of at least 180 feet and apparently are un-

[18]Choffat, Paul, and de Loral, P., loc. cit.
[19]Haug, Em., loc. cit., p. 911.

conformable. There has been movement which tipped the bituminous bed to a westward dip sometimes as high as 45 degrees. No doubt these Cretaceous sediments covered the country much farther to the east and erosion subsequent to the movement has removed them. The occurrence of soft beds beneath the bituminous sandstones and above mashed quartz diorite has been noted. It is possible that these sands and clays represent lower Cretaceous sediments which acted as a buffer between the bituminous limestone and the quartz diorite during the movement.

TRANSITION AREA

The transition area is largely composed of igneous and metamorphic and Palaeozoic sedimentary rocks. The backbone of the Crystal Mountains, according to Ball and Shaler, consists of mica schists, sericite quartzite interbedded with chlorite and epidote schists representing either basic lavas contemporaneous with the sedimentary rocks, or very ancient intrusive bodies of igneous rocks. Later intrusions of granite and gabbro have been mashed and recrystallized into gneisses. To the east of the Crystal Mountains are limestones and calcareous schists.

The crystalline and folded area to the west of these mountains has been included in the transition area. There exists in this region metamorphosed sediments and igneous rocks. They are chiefly of interest as petrographic problems. East of the Crystal Mountains the sediments (Devonian?) become flat-lying and are covered by the sediments of Permian and Triassic ages in the interior plateau region.

The interior plateau region has been the subject of several recent papers by S. H. Ball, M. K. Shaler, J. Cornet, M. Leriche, R. D'Andriment, Maurice Robert, G. Passan and others. Below is the stratigraphic column in general as given by Cornet.[20] The order from top to bottom is from youngest to oldest:

[20] Cornet, J., Ann. Soc. Geol. de Belg. XXXVIII, Sur la possibilite de gisements de petrole au Congo, P. 305. 1910-11.

Formations not deformed	A.	System of Bussia fluvio-lacustrine recent deposits of the Haut Congo.
	B.	System of Lubilache, soft red and whitish sandstones with nuts and banks of hard sandstone.
Formations slightly deformed	C.	System of Lualaba, shale, sandstones, incoherent limestone often oolitic, bituminous shales. fossiliferous.
	D.	System of Kundelungu, sandstones, psammites, conglomerates.
Deformed	E.	Primary, divisible into several systems more or less metamorphosed. Archaean.

The prevailing conception is that systems A, B, C and D are more or less of continental origin. The Congo interior is presumed to have been a great pre-Permian basin in which there existed a large body of water either connected with the sea continuously or discontinuously. The eastern part of the interior between Stanleyville and Kasongo (both points are on Upper Congo River or Lualaba) has yielded fossils that have been studied and correlated by M. Leriche.[21] The fossils are chiefly fish remains and the ostracod *Estheria*. This ostracod is a fossil found in former arid regions where the lakes were subject to seasonal change. Cross-bedding in the Lubilache is frequently observed. The lack of fossils of marine type is also indicative of continental deposits. Near Nyangwe on the Lulaba there are salt deposits. A study of the salt deposits might indicate clearly whether this basin was closed or open to the sea.[22]

For these deposits there necessarily existed a land mass source. Davis in his "Observations in South Africa" supposes a land mass to the northwest of the veldt to have provided the material for the Karoo formation. Such a formation could furnish material to Central Africa as well as to South Africa.

This corresponds roughly to the southern rim of the Congo as described by Ball and Shaler. Possibly a land mass existed in Eastern Africa and furnished sediments to the west. This would agree well with the prevailing trade winds with

[21]M. Leriche, Ac. des Sc. de Paris, CLI, p. 840. 1910.
[22]Grabau, A. W., Principles of Stratigraphy, pp. 347-380. 1913.

consequent precipitation and give conditions similar to that of our Great Basin region of today.

It is interesting to note here a possible correlation of the consolidated beds of glacial till, described by Ball and Shaler on Lualaba River, with the Dwyka of the Karoo formation of South Africa. This is based wholly on lithological similarities. Near Langsburg, South Africa, the Dwyka commences with a soft shale in which are embedded scattered fragments of rocks ranging up to one foot in diameter. It was thought that this bed was deposited in a lake adjacent to and caused by the glacier of the time. A bed of this nature exists in the Maniema which is several hundred miles north of Rhodesia.

The possible correlation betwen Cornet's formations, the Karoo and the standard divisions is here presented:

	S. Africa	Belgian Congo	Germany	United States
Karoo	Stirmberg	Lubilache	Keuper	Triassic
	Beaufort	Lualaba	Bunter?	
	Ecca	Kundelungu	Permian	Permian
	Dwyka			

The fourth province at least in the Maniema, contains largely rocks of Paleozoic and possibly some pre-Cambrian. In the Maniema Ball found a patch of Lubilache in the headwaters of Luiko River resting unconformably on the older rocks. No doubt much of the eastern edge of this province has been covered by later sediments, but uplifts followed by erosion caused them to disappear.

Gneiss, quartz schist, and mica schist predominate. The schists are highly inclined (45 degrees at the headwaters of the Minimati) and dip to the west. The gneiss seems to be much like the contorted and gnarled gneiss which G. L. Collie finds to be the basement rock east of Lake Tanganyika. He likewise mentions Tertiary lavas while Ball mentions Tertiary outbreaks on the western side of the lake. Thus there seems to be a geological as well as a physiographical bond between the extreme eastern Congo and British and German East Africa.

OIL POSSIBILITIES

The discovery of oil shale in the Congo Basin and of a bituminous limestone on the west coast are encouraging. For the present we may say that there is a thirty to forty mile strip along the west coast extending north and south from the mouth of the Congo approximately 800 miles which may prove oil bearing. This strip is underlain by petroliferous Cretaceous rocks and it seems probable that folding is present. The British have obtained some oil to the north presumably in this Cretaceous series. Oil shale in the interior indicates the presence of sediments favorable for the accumulation of petroleum. Where regions of folding are found, it is quite possible that pools may in future be developed.

The work of exploration and development naturally will be more expensive and difficult than in the United States or Europe. It will be necessary to build roads for the transportation of machinery and supplies to points away from the navigable rivers and railroads. Because of the latitude, efficiency of labor will be about fifty per cent. No doubt in time the Congo as well as other parts of Africa will be drilled for oil, since any country with slightly disturbed sedimentaries is a possible future oil country, especially where oil is found in outcropping rocks.[23]

[23]It is known that the Exploration branch of the Sinclair Consolidated Oil Corporation has a party examining a portion of Angola. This is Portuguese territory adjoining the Congo on the south. The position of the parties indicates exploration of both the coastal and interior regions. Unofficial reports indicate that Algeria in Northern Africa is not as promising as at first presumed, seven dry holes having been drilled.

DISCUSSION

A PROPOS "THE SCIENCE OF PETROLEUM GEOLOGY"

To the Editor:

* * * * * * * Does the mental caliber or idiosyncracy, if you please, of the average good geologist comport with success in business? Or to express it somewhat differently, would a man enter upon a geologic career who has the elements of the mentality of the average successful business man? From my own observations of the mental make-up of the many geologists with whom I have come in contact, I should say decidedly "No!" Of course there are exceptions, and some of them have proved noteworthy, but nevertheless, my personal conviction is that those instincts which draw a man into the natural sciences are widely divergent from those which attract a young man into business. Such a mental change could be developed in time, however.

I should be glad to have this theme developed in the columns of the Bulletin. * * * * * * *

Yours truly,
W. C. PHALEN.

Syracuse, New York.
November 12, 1921

ON "DRILLING OIL WELLS WITH THE DIAMOND DRILL"

Beginning on page 387, Vol. 5, No. 3, of the Bulletin of the American Association of Petroleum Geologists, there appears an article by Frank A. Edson on Drilling Oil Wells with the Diamond Drill.

During the early part of 1917 the writer was concerned with the extension of shallow pools in parts of Oklahoma where sand conditions rather than structure seemed to be the predominating influences in the accumulation of petroleum. It became a difficult task to determine the shape of the edges of the reservoirs with the meagre and unreliable well records which were available, so that a realization of the value of cores of the sand bodies and adjacent strata prompted the writer to study the possible application of core drilling to the development of prospective and producing properties.

This study induced the writer to publish an article in the July, 1917 edition of the Oil Trade Journal, now known as the Fuel Oil Journal, entitled, "Core Drilling as Applied to the Development of Possible Oil Producing Territory," setting forth conditions other than structure which have caused accumulation or trapping of oil in commercial quantities and the use of cores relative to origin, porosity, saturation, extraction, thickness of sand, wildcatting in territory where structure is not indicated by surface exposures, proper location of tests with respect to structure where present, economic spacing of wells in producing territory, decline and shooting of wells.

The cost of core drilling as compared to standard methods employed at that time led me to believe that core drilling would find its greatest application in shallow territory.

As the result of comment upon this article from practical men the writer concluded that in order to meet the requirements for which core drilling is intended that some method must be adopted which will permit the making of more hole per shift in strata from which a core is of limited practical value, that the holes must be finished the sizes of regular oil wells and that inasmuch as all core drilling methods require the circulation of water in and about the cutting medium, it would be necessary to obtain a good sized core, so that the washing of the water on the core would not destroy its use in determining the porosity, saturation and extraction factors of the sand.

In unconsolidated or partly consolidated strata, where the standard rotary method of drilling is used, the core barrel method of obtaining cores is doubtless as satisfactory as can be expected; however in consolidated strata where the standard churn drill is used cores can not be obtained in this manner.

The diamond drilling equipment manufactured to date can not meet the above requirements because of the small sizes of cores obtainable. Should the manufacturers increase the sizes of their present equipment, the cost of the bit alone required by oil well drilling would exceed the cost of the rest of the equipment. The wear on the carbons depends primarily upon the care and skill of the diamond setter and drill runner. It is frequently necessary to purchase a duplicate set of bits so that work may progress while the diamonds are being replaced or reset in a worn bit. The wages of an expert diamond setter are to be added to the labor charge against the bit. A lost diamond bit means the loss of a large amount of money.

Investigation of various core drilling methods resulted in the selection of the Calyx core drill with walking beam as being the best adapted to the drilling of oil wells. This equipment is a combination of churn drill, operating in a manner similar to our present standard tools and a rotating core drilling equipment in which the cutting medium is chilled steel shot. The churn drill can be used to make hole faster than is possible with the core drill, until a core is desired, when the Calyx bit with the steel shot can be put into action for hard rock such as limestone and sandstone or the Davis cutter for softer strata such as shale. The Calyx bit is capable of taking large cores up to 20 inches. However, it is probable that a six inch core would be large enough for oil wells. Such a combination has all the advantages of a diamond drill for oil well drilling except that flush joint casing can not be used until it is desired to take a core.

The first cost of the Calyx drilling equipment with walking beam would be approximately the same as a diamond drill with duplicate set of bits. Repairs and maintenance are likely to be much more with the

diamond drill as there is no comparison of bit wear and replacement between the Calyx drill and the diamond drill. The speed and pressure required on a diamond bit result in heavy stresses on the machine whereas the weight of the rods and slower speed of the Calyx bit result in much smaller stress on its machine. There is little advantage in favor of either type of drill as to power.

Labor costs are less with the Calyx drill with walking beam because more hole is made per shift when walking beam is used and to the labor costs of a diamond drill the wages of an expert diamond setter must be added.

It is questionable whether core drilling can ever be undertaken at less cost than our present standard methods, however with an increased demand for the Calyx drill with walking beam or modification of these the manufacturers will be able to reduce their production costs and with the advent of more skilled labor in the handling of this equipment it will be possible to reduce the total drilling cost per foot. Such can not be hoped for the diamond drill for with an increased demand would come an increase in the price of the "black diamonds." The Calyx bit is the result of commercial conditions demanding a more economical method of core drilling eliminating the use of costly carbons.

When it is considered that the more accurate data obtained from cores may necessitate the drilling of a fewer number of wells to drain a property, and by proper spacing to increase the recovery factor or possibly lead to the discovery of new pools, the extra cost of core drilling while in the experimental stage, would likely be more than offset.

For detailed descriptions, pictures, use and cost data the reader may refer to the manufacturers. Ingersoll-Rand Co., New York.

CHAS. E. STRAUB.

Wichita, Kansas.

GEOLOGICAL NOTES

A GRAPHIC MODEL OF THE TEPETATE-CHINAMPA POOL IN THE MEXICAN FIELDS

The model illustrated in the accompanying cuts was built by the author for use by the attorneys of one of the large producing companies in the Mexican fields, in their defense against a lawsuit brought by an individual with whom they had a development contract for the development of certain leases in the Tepetate-Chinampa pool. The evidence involved questions of oil drainage and its accompanying saltwater encroachment, which in turn brought out the necessity of evidence as to the location of certain leases on the producing structure, the differential porosity of the pay formation in certain localities, and the time of flooding of certain wells in relation to other wells.

As the attorneys on both sides are usually but slightly familiar with the geological problems involved, and often know practically nothing of producing conditions, while the judge or jury may be in a similar situation, some graphic method of presenting testimony in a readily understood manner is desirable. This model was therefore built with a twofold purpose. The first purpose was that of enlightening the company's attorneys as to the relations existing between the various factors involved, and secondly to furnish an easily understood graph which could be used as evidence before the judge and to which reference could be made as certain other testimony was introduced.

The model consists of a sub-surface section, showing the folding in the Tamasopo limestone, on the top surface of which are drawn the oil-saltwater contact lines at different periods in the pool's history. This sub-surface section was built to scale by cutting out paste board contours, which were superimposed upon one another, and the edges filled in and smoothed with modeling clay. The form was then cast in plaster, after which the legend was colored in with water colors.

The surface section is represented by a sheet of transparent celluloid such as that used for plane table work, upon which is drawn the map of the district represented, directly above the folded Tamasopo section. Wooden pegs were inserted in perforations made in this transparent surface section, extending to the top of the Tamasopo below, where they were securely driven into the plaster. These represented the wells drilled within the area in question. The whole model is very simple in construction, and readily visible from all angles, as will be seen from the illustrations.

While such a model cannot be constructed progressively as a pool is developed, as can the peg models used by the Bureau of Mines it does have the advantage of being pictorially a better graphic representation of underground conditions, and can be more readily understood at a glance. For this reason it is adapted to court room use. When the contensions in any particular suit involve the question of the drainage of

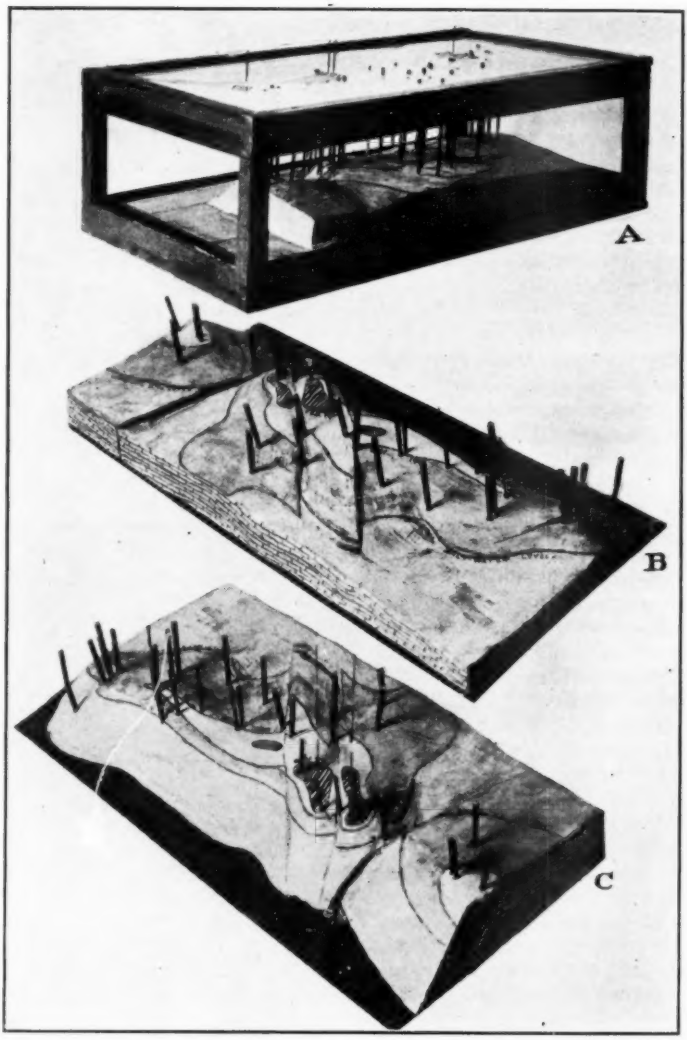

Plate I. *A*. Graphic model showing folding in the Tamasopo limestone (pay formation) and producing wells in the Tepetate-Chinampa oil pool, Vera Cruz, Mexico. *B*. Birdseye view of the underground folding from the east, as shown in the model *A* with the surface plan removed. *C*. Birdseye view of the model from the west, showing salt water invasion in the pay formation at different periods.

Prepared by Johnson, Huntley & Somers, Pittsburgh, Pa.

oil between leases several miles apart, a small scale model will tend to concentrate the various underground phenomena into such a small unit that it may detract from the strength of the contention as to distance. For this and other reasons it may perhaps not be felt advisable to put the model into evidence, but to hold it in reserve for use in case the plaintiff tries to introduce other testimony which it could be used to controvert. Its principal value in such a case would therefore be outside the court room, in building up the plan of defense for the company, between the attorneys and the geologists.

L. C. HUNTLEY.

FIELD WORK IN THE OUACHITA MOUNTAINS

Chas. W. Honess, Field Geologist, Oklahoma Geological Survey returned Nov. 10 from four months of field work in the Ouachita Mountains of Oklahoma. The greater part of his time this season was spent in northwestern McCurtain County and in southern Le Flore County south of Kiamichi River. The work consisted in mapping the areal geology and structure of the region.

He reports in this limited area of Jackfork sandstone and Stanley shale, the presence of three large, six to ten miles broad, relatively deep westward plunging asymmetrical synclines having a dip of fifteen to twenty-five degrees on the north side and a dip of forty-five to ninety degrees on the south, in each instance. These structures are separated one from the other by east-west faults but whether they are of the normal or reverse type he is not yet prepared to state.

Of special interest is the discovery, in this area, of a new fauna occurring in the Jackfork sandstone, calculated to be 6,000 feet above the base of that formation, yet several hundred feet below the top of it. The fauna contains bryozoa, brachiopods, pelecypods, gastropods, cephalopods,crinoids, and trilobites, and is in a good state of preservation. A preliminary report upon the fauna may be expected some time within the next year.

REVIEWS AND NEW PUBLICATIONS

PETROLEUM PRODUCTION METHODS

By John R. Suman, Gulf Publishing Co., Houston, Texas, 1921, 9x6 cloth, 556 pp., 200 figs. Price $6.00

This publication represents the closest approach yet made to what may be called a complete survey of the development, operation, handling, treatment, transportation and storage of crude petroleum.

It has been the aim of the author to compile a volume covering the technology of petroleum production as practiced by American operators.

Among articles especially written for this book by men well fitted to handle the subjects they discuss are; The Blowing of Wells With Compressed Air, by J. A. Tennant; The Performance of Rock Bits in Rotary Drilling, by Harold Fletcher and The Application of Diesel Engines to Pipe Line Pumping Stations, by H. R. Luke.

Numerous articles published by the U. S. Bureau of Mines and in various technical journals, some of the latter, the results of Mr. Suman's research and experience, are freely quoted.

In order to indicate the large number of subjects treated and to eliminate the necessity of inadequately discussing these in a brief review, the table of contents is quoted below.

The volume contains numerous photographs and diagrams of tools, machinery, apparatus and methods, which together with graphs and tables add greatly to its value in illustrating typical and special oil field problems and the most economic and efficient means of solving them.

The work is unique in that no mention is made therein of the application of geology to production methods, outlines for drilling campaigns, casing-head, gasoline and refining plants, or accounting systems for oil companies.

The book is a much needed addition to the literature on petroleum technology and should be welcomed by General Managers, Production and Field Superintendents, Drillers, Tool-Pushers, Pipe Line Engineers, Geologists and all those interested in developing petroleum properties.

CONTENTS

Derricks and Rigs—Rotary Rigs—Cable Tool Rigs, North Texas, Imperial Ideal—Combination Rigs—Development of Steel Rig—Methods of Guying Derricks.

Progress Charts for Drilling Wells.

Fire Hazards Around Drilling Wells.

Chapter II—Methods of Shutting Off Water: Cementing—Plug System—Dump Bailer Process—Cementing Without Plugs or Barriers—Tubing Method of Cementing—Gulf Coast Method—Amounts of Cement Needed.

The Use of Hydraulic Lime—Packers, Bootleg Packer System.

The Tamping Method—Methods of Testing Water Shut Off—Casing Tester and Bailer.

Chapter III—Operation of Properties and Handling of Production: The Controlling of Gasses and Gushers—The Control Head—The Mortenson Well Capper—Special Methods Used in California—Closing in of Potrero del Llano Well—Gas Traps.

Swabbing—The Air Lift for Pumping Oil Wells, by J. A. Tennant—Lease Management in Gulf Coast—Recovering Oil from Unconsolidated Sands—Hot Oiling—Pumping Equipment.

Central Power and Jack Pumping Plants, by R. M. Barnes—The Marietta or Smith-Dunn Process—Extinguishing Burning Oil Wells—Extinguishing Burning Gas Wells.

Chapter IV—Treating Emulsions: General Considerations—Treating by Heat in Open Tanks—Treating by Heat in Closed Receptacles—Dehydrators, Topping Plants.

Treating by Electricity—Treating With Chemicals—Treating With Centrifuges—Combinations of above—Use of Oil Filters—Heat Exchangers.

Chapter V—The Use of Electric Power: Operation of Wells by Electric Power, by W. G. Taylor.

Comparative Costs of Developing Electric Power for Pumping, by S. G. Gassaway.

Possibilities of Diesel Engine Power Plants.

Comparison of Diesel Engines and Steam Turbines for Operating Electric Generating Equipment.

Electric Power Required for Various Oil Field Operations.

Table Showing Cost of Operating Leases Electrically—California.

Cost of Generating Electric Power with Diesel Engines (1916).

Chapter VI—Pipe Lines: Construction and Operation—Construction and Operation of Gas Pipe Lines—Construction and Operation of Pipe Lines in Mexico—Submarine Pipe Lines.

Friction Losses in Oil Pipe Lines—Development of Theory—Friction Losses of Pennsylvania and California Oils—Friction Losses of Heavy Mexican Oils—Friction Losses due to Elbows.

Oil Engines in Pipe Line Pumping Stations, by H. R. Lucke.

Operation and Adjustment of Steam Pumps.

Chapter VII—Tanks:—Strapping of Tanks and Preparation of Gauging Tables—Contract Specifications for 55,000-Barrel Steel Tank—Tanks With Wooden Roofs—Specifications for Fire Wall—Tank Earthwork.

Contract Specifications for Construction 750,000-Barrel Concrete Lined Reservoir—Design and Construction of Concrete Fuel Oil Tanks.

Fire Hazards and Precautions about Tank Farms.

Heating Coils for Fuel Oil Storage Tanks.

Chapter VIII—Tables and Useful Information:—Measurement of Flow of Natural Gas Wells—Pilot Tube Method—Minute Pressure Method.

Tables of Specific Gravity and Pounds per Gallon.

Tables for Determining True Baume Gravity at Various Temperatures.
Temperature—Volume Tables.
Tables of Heat Units per Barrel.
Tables for Testing for Impurities.
Tables of Dimensions of Pipe and Casing—Pipe and Casing Used in Gulf Coast Fields—Rotary Pipe—Special Rotary Pipe—California Special Casing—Oil Well Tubing—Drive Pipe.
Table Giving Collapsing Pressures of Lap-Welded Steel Casing.
Tables Giving Bursting Pressures of Pipe.
Table Showing Capacity of Tubing and Casing.
Table Giving Contents of Cylinders.
Auxiliary Apparatus as an Aid to Fuel Saving.
Details Concerned With the Making of Pipe Connections—Making of Tight Joints—Defects in Threads—Briggs Standard Thread—Length of Threads on Pipe—Expansion of Steam Pipes.
Details of Fittings.
Table Giving Strength of Bolts.

LEON J. PEPPERBURG.

Dallas, Texas, August 31, 1921.

PETROLEUM PRODUCTION METHODS,

By John R. Suman, Gulf Publishing Co., Houston, Texas, 1921

A book "Petroleum Production Methods," by John R. Suman, has been published by the Gulf Publishing Company, of Houston, Texas, "to get together in one volume a great deal of important data dealing with various phases of the petroleum industry, and thus to make accessible to the practical man a large fund of information which is only found in the transactions of the various technical societies." The book contains a description and discussion of the rotary and cable tool systems of drilling, giving specifications for derricks and rigs and the equipment necessary to drill wells in certain districts. Various methods of shutting off water are discussed. Other subjects covered are the operation of properties and the handling of production, the treating of emulsions, the use of electric power, pipe lines, and tanks. The last chapter includes tables and information which are always helpful to men in the field.

This book is of a handy size, the printing is well done, the quality of the paper is good and it is abundantly illustrated. In some cases the illustrations have been reduced too much and it is evident that the original photographs for making halftones were not clear. The printer has in a few places neglected to give due credit by foot note or other means to all material used,—for example, parts of the material on pages 10-11 on removing drill bits, is almost an exact copy from Catalog 9 Lucey Manufacturing Corporation, 1921, pages 148-149, but no reference is given.

A great deal of credit is due Mr. Suman because in his book he has put together much valuable information which is difficult to gather and compile. In fact those parts of the book dealing with drilling and production are the best compilation of published material. It is

obvious, however, that any publication can be improved, and in this publication certain improvements can be made. The writer is calling attention to certain places with the hopes that these can be changed in later editions.

Perhaps the most general criticism is that the book savors too much of the Gulf Coast point of view and problems. Another general criticism is an attempt to crowd too many subjects under one cover. To make this clear it is necessary to mention the status of the engineering profession in the petroleum industry today. It is now necessary for engineers to specialize on various problems such as development, pipe lines and refineries. This covers drilling and production, the pipe line engineer and the refinery engineer. It is obvious that a man specializing in drilling and production is rarely competent to determine the best method for treating emulsions. Emulsification is a different problem and the method for handling emulsions on any particular property can be handled best by a competent chemical engineer. Certain processes are applicable in one place while they fail elsewhere. Therefore the writer believes that books should be written for the services of engineers specializing in different subjects. For that reason it is believed that this book could be improved upon if Mr. Suman had enlarged upon parts of the book dealing with drilling and production and omitted that part treating with such subjects as emulsions. A proper place for enlargement would be the discussion of tanks in Chapter 7, where the subject of evaporation losses could well be covered. Evaporation is not a serious factor in the heavy Coastal crudes but it has been definitely established that millions of gallons are lost annually through evaporation from the lighter oils of the Mid-Continent, Wyoming and the Appalachian district. It has also been established that these losses can be eliminated almost entirely by the installation of tight tanks.

Chapter I, entitled "Drilling Methods," deals with the rotary and cable tool method of drilling, also derricks and rigs, progress charts for drilling wells and fire hazards around drilling wells. On the whole this is a very satisfactory chapter although there are certain places in need of improvement.

It is not clearly apparent why Mr. Suman is such an earnest advocate of the rotary system even in those places where it is best applicable. It is perhaps true that the rotary is the most adaptable in a region of loose running sands, such as the Gulf Coast region, north Louisiana and Arkansas, and in parts of California, but Mr. Suman's statements leave an erroneous impression about the value of the rotary to a part of the Mid-Continent, the Appalachian district and to parts of California. Throughout the book Mr. Suman seems to be an earnest advocate of the use of the rotary system and points out that it is possible properly to drill and core a well in such a way that the formations are definitely known from top to bottom, also that there is no necessity of

passing up producing oil sands. It is perhaps true that this can be in many other place the rotary method of drilling is not successful in many othher places the rotary method of drilling is not successful in locating all of the upper sands capable of producing. It is also true that the rotary method of drilling has behind it a very unsatisfactory record in wild cat work. For that reason even though the rotary method can perhaps be used successfully in wild cat work still it must be recognized that cable tool drilling has been much more successful in the past.

In covering the rotary system of drilling it would seem to the reviewer that an improvement could be made in the text by handling the subject according to different districts, that is, give first a general discussion of rotary drilling followed by a discussion of the special practices in the different districts such as (1) the Coastal fields of Texas and Louisiana, (2) North Texas, North Louisiana and Southern Arkansas, (3) California and (4) foreign pratices. This would be helpful because while the principle of rotary drilling is the same, conditions in the various districts demand certain modifications of the equipment needed and a description could be given of the practices peculiar to each district.

Certain detailed criticisms could be made. For example, the list of materials and tools required in the drilling of rotary wells in north Louisiana as covered on pages 14 and 15 is not complete. The most striking criticism of this list is that there is no provision for drill pipe.

The article on the rotary rock bits starting on page 18 is very good, especially the informaton on the proper weight to put on a bit, the speed of pumps and the speed of rotation necessary for efficient drilling in hard rock. This aricle was written by Mr. Fletcher, of the Hughes Tool Co., and naturally the illustrations used by Mr. Fletcher are those of the Hughes Tool Co. While the Hughes bits are satisfactory, still it would seem that information should be given on other satisfactory rock bits, for example, the Reed Rock Bit and Reed Reamer. It would have been interesting to include in this article the advantages and disadvantages of the various bits and the application of each one to the district in which it is most successful. It is also noticeable that there is no particular mention of fish tail bits which in fact drill most of the hole in rotary drilling. The discussion of the Hughes pattern of rotary tool joints of the Guiberson patent is very good, but all tool joints are not discussed. For instance, the Hickman tool joint is used almost exclusively in north Louisiana and deserves mentioning

The article on the sampling of formations in rotary drilled wells is good, and it shows that true samples of formation can be taken from rotary drilled wells.

The use of screen pipe is only briefly discussed and it would have added to the book if a brief summary had been given of the values of shop perforated pipe, screen pipe, and pipe perforated in the well.

The adaptability of each kind and their advantages and disadvantages should be included.

The discussion of the use of the canvas adapter packers used in the Gulf Coast fields is incomplete. For the same purpose other lead and canvas packers besides the Layne and Bowler packer which is described on page 44, are used extensively; for example, the Evangeline Iron Works packer, the Getty packer, and the Getty-Gulf packer.

The article on blow out preventers could have been more helpful if descriptions had been given of the various blow out preventers used in the fields where drilling is done by the rotary system. For instance, in the Coastal fields there are types commonly known as "boll weevil", the leaded nipple and the control connections commonly called by the field men "the Christmas tree."

The cable tool method of drilling is discussed in more detail than the rotary system. This part of the book discusses in a very satisfactory way cable tool drilling, fishing jobs and tools, various type rigs, etc. But here also the application of the cable tool system could be discussed so that the reader would understand its use and requirements necessary to meet the particular conditions of each district.

Chapter II on the "Methods of Shutting off Water" is a good summary of information now available on this subject. While the discussion of the plug system of cement is good, the Halliburton cementing process deserves consideration. This process has been developed in the Oklahoma fields and has an advantage over the other plug systems in that a measuring line is attached to the top plug. This insures the exact position of the plug from time to time. Likewise no particular mention is made of the much used "one plug method", used in rotary drilling in northern Louisiana and southern Arkansas.

Chapter III covers the "Operation of Properties and Handling of Production." There is a good discussion of control casing-heads and also of gas traps although there is no mention of the control methods used by the rotary system of drilling. The swabbing of wells is discussed but inasmuch as there is considerable question as to whether or not the same results can be accomplished by pumping and vacuum, it would be proper to discuss the relative merits of swabbing and vacuum.

The recovery of oil is a big subject and parts of Chapter III are very good, but in other cases the discussion is brief and general. For instance, the surface equipment for recovering oil with the jack system is described in detail, but other methods are only briefly discussed or are not mentioned.

Much more detail should be given the subjects of pumps, sucker rods and tubing, as well as standard equipment for pumping wells with the individual power units. On page 277 the discussion of tubing catchers is entirely inadequate when considering the importance of this equipment in successful oil field operation.

On pages 318-319 the discussion of the Smith-Dunn process for increasing the recovery of oil is inadequate and does not include the latest information upon costs. The application of the principles underlying the Smith-Dunn process possesses wonderful possibilities for the future and will be a very important factor in increasing the recovery of oil from our known reserves. This particular process is very successful in the Appalachian district and will undoubtedly become increasingly important in the Mid-Continent. It is today successfully used in Kansas. The Smith-Dunn process is fully described in Bulletin 148, U. S. Bureau of Mines.

Mr. Suman has also failed to discuss the merits of flooding as practiced at Bradford, Pa. Some very satisfactory results for increasing the production have been accomplished in that district. Neither under the general subject of increasing recovery is there any mention of the use of electrical or steam heating, the use of acids or other solvents for removing deposits from the pores of sands, except that part dealing with "hot oiling" on page 287.

Chapter IV is entitled "Treating Emulsions." There is nothing new in this chapter, and most of the material is presented is an empirical form. Apparently all of the ordinary methods of treating emulsions have been covered, but little information is given as to the relative merits of different processes and what kind of emulsions each one is best suited for. The section dealing with treating of emulsions with chemicals is particularly defective and deals principally with the use of Tret-o-lite without giving any particular idea of what the material really is. The only centrifuge which is mentioned is the Sharples super-centrifuge, the description of which is quoted apparently from advertising matter. No discussion of the actual nature of the emulsion is given, and no mention is made of a considerable amount of recent work which has been published in regard to the colloidal nature of emulsions.

On account of space alloted to this review detailed criticism of chapters V, VI, VII, and VIII cannot be given. On the whole these are very satisfactory and while subject to some criticism they represent a collection of very valuable information.

In chapter V Mr. Suman has brought together some good information on the use of electricity in oil field operation.

Chapter VI covers pipe lines; Chapter VII, tanks, both steel and concrete lined reservoirs, while Chapter VIII is a set of tables and other useful information.

It is much easier to criticise special points of weakness in a publication covering the many subjects discussed by Mr. Suman than to write a similar book of this nature. While some parts of this book could be improved upon still to anyone familiar with publications of this sort, the compilation of the data for this book and its preparation and publication represent an enormous task. Mr. Suman has suc-

ceeded in compiling the best published material and augmented this by some of his own material. The book should be helpful to those requiring information along the lines covered, and it is a book that will be of real service to engineers in drilling, production, and development.

A. W. AMBROSE.

PETROLEUM ENGINEERING IN THE DEANER OIL FIELD OKFUSKEE COUNTY, OKLAHOMA

This report on the Deaner Field is one of the most comprehensive yet issued by the Bureau of Mines in mimeograph form. It comprises 72 pages mimeographed on both sides of the page with 9 tables and 22 illustrations. It is published by the Bartlesville Chamber of Commerce and can be procured from them at a cost of 50 cents per copy. A number of questions are discussed in this Bulletin among which are the effect of back pressure on wells, gas anchors in pumping wells, a simple method of arranging tanks for measuring the daily production of wells, forms of gas traps, water problems and the use of mud-laden fluid in drilling. Decline curves for production in the pool have been prepared with the co-operation of Mr. W. W. Cutler, Jr., who wrote the portion of the new Manual for the Oil and Gas Industry published by the Treasury Department which deals with the drawing of curves It is estimated that the Deaner Pool will cover an area of 650 acres and will ultimately produce 4,666,000 barrels of oil or 7,000 barrels per acre.

SIDNEY POWERS.

NECROLOGY

CAPTAIN ANTHONY F. LUCAS

Captain Anthony F. Lucas, the discoverer of Spindletop and a member of the American Association of Petroleum Geologists, died suddenly at his home in Washington, D. C. on September 22, 1921.

A biographical sketch has recently been published of Captain Lucas by H. B. Goodrich in the November number of Mining and Matallurgy, and the chief events of his career are therein concisely set forth. They may be repeated here.

Captain Lucas was born in Dalmatia, Austria, in 1855, of Montenegrin ancestry. He was graduated as an engineer at the Polytechnic of Gratz and served in the Austrian Navy as second lieutenant. In 1879, he obtained leave of absence and visited an uncle in the United States. After an extension of this leave of absence, in order to undertake an engineering engagement in the lumber district of Michigan, where he resided, he decided to become an American citizen. He was naturalized in May, 1885.

His name was Luchich, but as his uncle had adopted the name of Lucas, which was more easily pronounced by Americans, from his entrance to this country, he used this Anglo-Saxon form. Without knowing this fact, on first meeting him a person was sometimes surprised to note the rather Germanic pronounciation of the Captain.

Although he subsequently revisited Austria with Mrs. Lucas, he made his permanent home at Washington, D. C. His son served with distinction in the A. E. F. during the World War.

Captain Lucas became a member of the A. I. M. E. in 1895. During 1914, 1915, 1918, and 1919, he was chairman of the Petroleum and Gas Committee of the Institute and was at all times prominent in Institute Affairs.

Among his contributions to technical literature were: Geology of Sulphur and Oil of the Coastal Plains, **Journal Eng. Chemistry,** 1912; A Review of the Exploration at Belle Isle, Louisiana, **Trans.** (1917) 57; Possible Existence of Deep-seated Oil Deposits on the Gulf Coast, **Trans.** (1919) 61; Urgency for Deeper Drilling on the Gulf Coast, **Trans.** (1921) 65. He also took a most active part in all discussions relating to petroleum of the Gulf Coast and the salt-dome theories.

Among other societies of which he was a member are: The A. A. A. S., Franklin Society, Washington Society of Engineers, and the Geological Society of Washington.

The activities of Captain Lucas as a mining engineer in this country were first in Colorado. His connection with the Gulf Coast in which his chief work was done began in 1896. In this year he undertook an engagament from Joseph Jefferson, the actor, to drill a well on the Jefferson estate in Louisiana, known as Jefferson Island. Jefferson Island was one of the well known Five Islands of Southern Louisiana, and was selected by Jefferson as a site on which to build a winter home because of its elevatcd position.

Because of the presence of mineral springs at the surface, Jefferson conceived the idea of boring a well in search of health giving water, and Lucas undertook this work for him.

While engaged in drilling this well, Lucas discovered at a depth of 290 feet a magnificent bed of rock salt. This discovery was followed by other explorations determining an area within which rock salt was encountered at from 90 to 300 feet from the surface.

In 1897, Lucas extended his operations to Belle Isle and Grand Cote, also members of the Five Islands group where the topographic expressions and the surface conditions were similar to those which he

had seen at Jefferson Island. In both of these places he likewise succeeded in discovering salt.

During the explorations at Belle Isle, Lucas discovered in the cap rock above the salt, indications of petroleum, and several beds were encountered containing considerable quantities of sulphur suggesting to him that more thorough exploration might develop a sulphur deposit similar to that at Sulphur, Louisiana. And it was probably with the idea in mind of locating another sulphur deposit like that at Sulphur that Lucas extended his investigations into Texas. However, it is doubtless true that he was not unmindful of the possibities of finding oil in commercial quantities at likely looking spots in Texas, in view of the indications of oil he had seen at Belle Isle.

Lucas appeared in Texas about 1899, and was impressed with the similarity of the surface indications at Spindletop, to those existing at the Five Islands. Attempts had been made at Spindletop to find oil 7 years prior to the appearance of Lucas, for in 1893 a company was formed at Beaumont, by Patillo Higgins for the purpose of exploring the Spindletop locality for natural gas, oil and sulphur. The second attempt to find oil at Spindletop was in 1894, by Walter Sharp. And again in 1896 and 1898 wells were drilled at this spot in search of oil. None of these wells proved successful, because the operators could not penetrate the immense thickness of quick sand which here underlies the surface clay.

Lucas attacked the problem by use of the rotary system of drilling which he had used in his Louisiana explorations and which was first devised by Walter Sharp.

Boring in the original Lucas well was begun about the middle of October 1900. After contending with many difficulties, financial, mechanical and otherwise, Lucas succeeded in bringing in the famous Lucas gusher in January 1900 at a rate estimated at 125,000 barrels per day.

This discovery by Lucas gave an enormous impetus to the oil industry and it marked the beginning of its expansion to the present gigantic proportions. It is safe to conclude that the Lucas discovery was second only in importance to the discovery by Drake, in Pennsylvania, in 1859, and when the history of oil is finally written the name of Lucas will occupy a most important place in this story.

Personally Captain Lucas, was a very pleasant man to meet, and he gave one the impression of being a thorough gentleman, genial and obliging, and impressed with a keen scientific spirit.

His career has demonstrated in a most remarkable way what the application of science and engineering can do in the recovery of this most important substance in the world economy, and all petroleum geologists and, particularly, the members of this Association can do well to be guided by his splendid example.

ALEXANDER DUESSEN.

Houston, Texas, November 30, 1921.

AT HOME AND ABROAD

MR. WOOD STANLEY has accepted a position with the Gulf Production Company at Mexia, Texas.

MR. ED L. ROARK is with the Marland Refining Co.

MR. FORREST L. REES is Chief Geologist for the Skelly Oil Co., at Tulsa, Okla.

MR. J. W. BOSTICK has been in Mexico for the Kansas & Gulf Oil Co.

MR. CLIFTON M. KEELER, formerly Consulting Geologist in the Mid-Continent oil fields, who has had several years experience in home and foreign fields, has recently been appointed Valuation Engineer in the Oil and Gas Section, Bureau of Internal Revenue, at Washington. His present address is 614 18th Street N.W., Washington, D. C.

MR. ROY BURT, of Independence, Kansas, located the well in Section 29, T. 23 S. R. 10 East, Greenwood County, Kansas, brought in by Roth &. Jones, November 25th.

MR. J. Y. SNYDER, of Shreveport, La., who discovered the Haynesville structure, has recently located the highest point of the Bodcaw Lake Anticline in NE¼ NW¼ NE¼ Sec. 15, T. 19 N., R. 11 W., Bossier Parish, La. The Hard Luck Oil Co., (R. O. Roy and J. Y. Snyder) brought in a well at 397 feet in the Nacatoch sand estimated as good for 1200 barrels of 19.2 gravity oil. This is structurally the highest point in Louisiana, 190 feet below sea level on the top of the Nacatoch. The highest points at Caddo and Red River-De Soto are both 550 feet below sea level. Possibilities in the Woodbine sand are untested. Mr. Snyder also located the Robinson-Fair Drilling Co.'s well in Sec. 4, T. 11 N., R. 11 W., De Soto Parish, La., which came in November 28th, estimated as 1,000 bbls. and in which he has a substantial interest.

MR. C. C. CLARK AND MR. GLENN LASKEY are with the Roxana Petroleum Corp. at Shreveport, La.

MR. GRADY KIRBY has returned from Venezuela and is with the Gulf Production Co., at Mexia.

MR. E. RUSSELL LLOYD, of the Mid-Kansas Oil Co., is working at Corsicana, Texas.

MR. W. C. MCLAUGHLIN is in charge of the subsurface work of the Gulf Production Company at Mexia.

MR. HECTOR CRANDALL has returned from Angola, West Africa.

MR. PAUL NAGLE is with the Empire Gas & Fuel Co. at Duncan, Okla.

MR. C. J. WOHLFORD is in charge of a well which the Amerada Petroleum Corporation is drilling near Ardmore, Okla.

PROF. J. VOLNEY LEWIS, of Rutgers College is in Mexico with the Mexican Eagle Oil Co., in charge of subsurface work.

THE SYMPOSIUM on Foreign oil possibilities of the American Institute of Minning and Metallurgical Engineers has been postponed until the week of February 20th.

THE AMERICAN GEOLOGIST returns the first of January, 1922, under the editorial direction of Dr. Charles R. Keyes, 944 Fifth Ave., Des Moines, Iowa.

MR. W. P. HAYNES and MR. F. B. ELY report an excellent assortment of igneous rocks in Northern Mexico, where they are working out of Tuscon, Arizona.

DR. E. T. DUMBLE has been in Tampico.

MR. G. A. TROENLIN, of the Sinclair Interests, has been transferred from Tampico to Tulsa.

The first dry hole in the Burbank field, Oklahoma, was completed Dec. 15th.

MR. M. M. GARRETT and MR. C. C. KING have returned from Angola, West Africa. They report that the first Angola well passed through Tertiary and Cretaceous oil sands and that heavy bitumen from a 2800 foot sand squeezed out of the casing one inch a day. Mr. Garrett is now with the Sun Co. at Dallas, Texas, and Mr. King with the Sinclair Oil & Gas Co., at Tulsa.

MR. R. M. WEAVER and MR. K. W. REYNOLDS are engaged in consulting work at Wynnewood, Okla.

MR. DONALD F. MCDONALD, of the Sinclair, spent the summer in Tampico and made a visit to New York before going to Central America, where he is looking over the Sinclair holdings.

MR. RICHARD T. LYONS has returned from Venezuela where he has been employed by Brokaw, Dixon, Donnelly, Garner and McKee, and is now with the Sinclair Oil & Gas Co., at Tulsa.

MR. W. J. DONOVAN is Chief Geologist of the Barnsdall Oil Corporation Petroleum Building, Tulsa, Okla.

MR. ALEXANDER DUESSEN spent several weeks during October in Tampico.

MR. LUTHER H. WHITE has been elected a member of the Board of

Directors of the Oklahoma Central Oil Company, which is now located in the Kennedy Building, Tulsa, Oklahoma.

MR. W. C. SPOONER, Chief Geologist of the Arkansas Natural Gas Company, has returned from Brazil and is now located in Shreveport, La.

MR. ROBERT T. HILL is representing the State of Texas in the Red River Boundary dispute and has spent a considerable amount of time in Washington in connection with this work.

MR. W. C. KINKEL spent the Summer in Wyoming and has now returned to work in Oklahoma.

MR. WALLACE C. THOMPSON, of the Sun Company, is located at Graham, Texas.

MR. G. C. POTTER of the Tidal-Osage Oil Company (Guffy-Gillespie Oil Company) is working at Mexia, Texas.

MR. FRANK EDSON is making a number of tests with a diamond drill in the Panuco Field and also along the Lagoon in Mexico for the Atlantic (Cortez) interests.

MR. G. E. SCOTT and MR. R. E. BENDING located the anticline in Section 7, Township 27 S. Range 11 East, Greenwood County, Kansas, where Jess Willard recently completed an oil well.

MR. E. DEGOLYER, AND MR. PAUL WEAVER spent the month of October in London. Mr. DeGolyer read a paper before the Society of Automotive Engineers on Oil Possibilities in Mexico, which is contained in the Oil & Gas Journal of Nov. 4th.

W. E. HUBBARD, of the Humble Company, has moved from Ardmore to Wichita Falls.

MR. J. C. ROSS, of the Sun Company, is stationed at Mexia, Texas.

MR. E. V. WOOLSEY, of the Atlantic Oil Producing Company, is resident geologist at Mexia, Texas.

MR. R. D. GOODRICH has established an office as Consulting Geologist at Mexia, Texas.

MR. DILWORTH S. HAGER is in charge of the work in Texas for the Gulf Production Company and has headquarters at Mexia.

MR. H. H. NOWLAN is Chief Geologist for the Bradstreet Oil Company, Cosden Building, Tulsa, Oklahoma.

MR. W. G. ADAMS is Resident Geologist for the Shaffer Oil & Refining Company, Kennedy Building, Tulsa, Oklahoma.

MR. W. M. BURRESS is now associated with the Marland Refining Company.

MR. S. J. CAUDILL has moved to 801 Cosden Building, Tulsa, Oklahoma.

MR. EVERETT CARPENTER has established an office as consulting geologist in Winfield, Kansas.

A MEETING OF THE COMMITTEE which has been estimating the petroleum reserves of the United States was held in Chicago during October. Mr. David White and Mr. K. C. Heald represented the United States Geological Survey. Another meeting will be held at Amherst, Mass., at the time of the Geological Society of America Meeting, December 28th to 30th.

MR. DAVID DONOGHUE has opened an office as consulting geologist in the Burkburnet Building, Fort Worth, Texas.

MR. L. P. GARRETT has been elected Vice President of the Gulf Production Company at Houston, Texas.

MR. K. D. WHITE has returned from Africa.

MR. C. W. WASHBURN has returned to New York City from a trip to South America which lasted several months.

A recent notice in these columns referred to the permanent address of MR. R. T. HILL as Los Angeles. His correct address is 623 N. Central Ave., Glendale, Calif.

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